

A Review of Our Knowledge of California Mecoptera

Norman D. Penny

*Department of Entomology, California Academy of Sciences, 875 Howard Street,
San Francisco, CA 94103, USA: Email: npenny@calacademy.org*

Nine species in eight genera of Mecoptera are probably found in California. More genera of Mecoptera occur in California than in any other state in the country. California representatives of Mecoptera also contain an unusually high number of basal species and their distributions are unusually small.

Mecoptera, or scorpion-flies, hanging-flies, and earwig-flies, are among the oldest holometabolous insects with fossils dating back to the early Permian, 250 million years ago. By the late Permian they were quite abundant (Carpenter 1931; Riek 1980). Fore- and hind wings have very similar venation that has remained little modified over hundreds of millions of years. Most mecopterans have a distinctive long rostrum with mouthparts at the end. Most species are saprophagous or phytophagous, but members of Bittacidae are predaceous. They are found all over the world, but tend to be more common in temperate regions; and some groups, like Boreidae in northern boreal climates and Apteropanorpidae in Tasmania, are highly adapted to colder temperatures.

In the United States, Mecoptera are thought to exist primarily in the eastern part of the country. When Carpenter (1931) wrote his revision of the 54 species of Nearctic Mecoptera, there were only seven species known from the western part of the country and only three species from California. Byers' (1954) report on the Mecoptera of North America included 70 species, 16 of which (mostly *Boreus*) were western and still only three species from California. This seems strange in light of the relictual nature of many faunal elements (Rasnitsyn 1997; Vickery and Sandoval 2001; Wygodzinsky 1961) in the Mediterranean climate of California and the long, rich geological history of Mecoptera (Carpenter 1931, 1992).

The Mecoptera that do exist in the western U.S. were generally thought to be Boreidae (winter scorpion-flies) in the Great Basin and high mountains, two species of *Brachypanorpa* in the Northwest, and two species of Bittacidae (hanging-flies) in coastal California.

However, a more complex picture of mecopteran distribution recently has begun to emerge. Several new species have been discovered with very small distributions (Cooper 1972; Villegas and Byers 1981; Russell 1979; Byers 2005). Today, eight genera are likely found within the boundaries of the state, and with no more than six genera found in any other state, California could arguably be considered to have the most taxonomically diverse fauna in the country.

The purpose of this paper is to draw the attention of the scientific community to the importance and diversity of the fauna of California, in this case with specific reference to the Mecoptera, and to report briefly on what is currently known about the California species and their distributions.

Family Bittacidae (hanging-flies)

These insects look like four-winged crane-flies, hanging by their forelegs from vegetation. Some species rest with their wings open, others with wings closed, and in California there is one species with no wings at all. Despite the common notion that mecopterans are predaceous, Bittacidae is probably the only predaceous family in the order. In this family, the hindleg is modified to include a single enlarged apical claw that is raptorial. The prey is transferred from the hindlegs to the forelegs for feeding, or in some cases is given to a potential mate as a nuptial meal (Bornemissza 1966). Larvae are eruciform and saprophagous, living at the soil surface, and feeding on dead insects and earthworms (Setty 1940).

The family Bittacidae, and notably the genus *Bittacus*, is distributed worldwide. Four bittacid genera have been reported from North America: *Hylobittacus apicalis* (Hagen) has dark wingtips and is found in river bottoms over much of the eastern U.S. (Byers 1979); *Bittacus* is represented by seven species, six of which are found commonly along streams and sometimes in open grasslands throughout the eastern U.S. as far west as eastern Montana (Byers 1973), and one, *Bittacus chlorostigma*, occurs in California; two additional genera, also known from California, are *Apterobittacus apterus* (McLachlan) and *Orobittacus obscurus* Villegas and Byers.

Bittacid species in the eastern U.S. lay eggs in mid-summer and larvae almost immediately hatch and begin development. By late summer the larvae are fully grown and overwinter as prepupae. The two lowland California species of bittacids lay eggs in April and May. Eggs have a pink coating and go through a five to six month aestivation. When the rains begin in the fall, eggs swell to twice their original size and the pink coating is cracked and broken and the eggs hatch. Larvae develop during the late fall and winter. Nothing is known of immature stages of *Orobittacus obscurus*.

Apterobittacus apterus (McLachlan, 1871)

Fig. 1.

This species is found in grasslands of the coastal hills and the Central Valley of California (Map 1). It was originally described from Brooklyn, California. The town once stood near what is now Mills College in the hills behind Oakland. This is one of two wingless species of Bittacidae in the world, the other being *Anomalobittacus gracilipes* Kimmins of South Africa.

Adults climb amongst the grass blades feeding on flies, caterpillars, and other insects that they capture with their raptorial hindlegs. Adults emerge from late March to early June. The larval stages were described by Applegarth (1939).

Because they are wingless, these mecopterans are vulnerable to population extirpation through fragmentation of habitat and subsequent habitat modification. Recolonization is difficult if roads, land cultivation, or other barriers to local dispersal exist.



MAP 1. Distribution of *Bittacus chlorostigma*, *Apterobittacus apterus* and *Orobittacus obscurus* in California.

Bittacus chlorostigma McLachlan, 1881

Fig. 2.

This species of rather large hanging-fly has one unmistakable characteristic—the pterostigma of the wings is bright yellow. They are found in open oak woodlands of the foot-hills of the Sierra Nevada and Sutter Buttes (Map 1), emerging as adults from late March to mid-July. They can be locally abundant at peak emergence. As with *Apterobittacus apterus*, the egg first goes through a long aestivation period before eclosion.

Orobittacus obscurus Villegas and Byers, 1981

These secretive and primitive bittacids are unusual in several respects. They have darkly infuscated wings and live in the shadows below rock overhangs and at the base of protruding tree roots. They are very sensitive to warm temperatures and females do not appear to drop eggs as readily as do other bittacids. Whereas all other North American bittacids are known to occupy ranges that extend for hundreds or even thousands of square kilometers, this species is known from only two small populations along the American River in the Sierra Nevada—at a U.S. Forest Service picnic area about 30 km east of Placerville (El Dorado County), and near Foresthill (Placer County) (Map 1). Adults emerge from early May to early July.

The male genitalia possess several characteristics that are strikingly unique among North American bittacids. The dististyles are enlarged, a characteristic that they have in common with *Tythybittacus maculpinei* Smithers of Australia and *Anabittacus iridipennis* Kimmins from Chile. As in these other two genera, the cerci are expanded. However, *Orobittacus* is unique in that the ninth tergum has developed into a single median lobe with terminal, claw-like spines (Villegas and Byers 1981). This species must have diverged from other bittacids at a quite early period to have these primitive features in common with species from Chile and Australia, and yet also to have developed such a remarkable and unique character.



FIGURE 1. *Apterobittacus apterus* (McLachlan). Photo by Vincent F. Lee.



FIGURE 2. *Bittacus chlorostigma* McLachlan. Photo by T.W. Davies.

Family Boreidae (winter scorpion-flies)

These insects are among the smallest mecopterans. Adults are about 3–5 mm long, brown to shiny black in color, have highly reduced wings, and emerge during the winter months in the lower 48 states. Females have an ovipositor that can be long (*Boreus*) or vestigial (*Caurinus*). Most species can be recognized as mecopterans by their long rostrum. Adults feed on the foliage of mosses, club mosses, and liverworts. Larvae are white, scarabaeiform and sedentary, and feed upon the rhizoids of the same plants as the adults.

The family is divided into two subfamilies (Russell 1979): Caurininae (*Caurinus*) and Boreinae (*Boreus* and *Hesperoboreus*). All three genera are probably found in California.

Genus *Caurinus* Russell

Caurinus decetes Russell, 1979

This is a very unusual insect. It is almost certainly a boreid, but lacks the elongate rostrum that is characteristic of all other boreids and most mecopterans. Males have reduced, spiniferous, strap-like forewings and females have rounded, short, forewing pads similar to most other boreids. However, unlike other boreids, hindwings are absent. The male has recurved dististyles, but females lack ovipositors. They are smaller than all other boreids, with overall length from 1.4–1.9 mm. Larvae are almost legless (Russell 1979). They are found in moist forests with abundant epiphytes and terrestrial bryophytes. Adults feed on the epiphytic liverwort *Porella navicularis* (L. & L.) Lindb., but they have also been found in terrestrial mosses (Russell 1979). They are distributed in the Coast Range of central Oregon. However, in his Ph.D. thesis Russell mentioned finding feeding damage from *Caurinus* on epiphytic liverworts in northernmost California and he believes that they exist there.

Genus *Boreus* Latreille

Boreus is the most speciose of the three genera of Boreidae. They can be distinguished by the rostrum which has a narrow hypostomal bridge. Males have the ninth tergum modified into a small to large hood to receive the recurved dististyles. Females have a long ovipositor that is about as long as the elongate rostrum. They are Holarctic in distribution (Penny 1977) and in North America are distributed in the cooler regions of the eastern U.S. (2 species), Alaska (2 species), and across the western states (8 species).

Boreus californicus Packard, 1871

Fig. 3.

This species was originally described from 3 males and 4 females from the east (Ft. Bidwell) and west (Goose Lake) sides of the Warner Mountains in Modoc County, California (Map 2). This is the most widely distributed species of boreid in western North America. They are found at high elevations from the Canadian Rockies of British Columbia and Alberta through Wyoming and Montana south to northern Arizona and California (Penny 1977). In California they can be found on tightly compacted *Grimmia* mosses in the Sierra Nevada and White Mountains. They prefer rock surfaces above 4000 feet from Yosemite National Park northwards to the Oregon border. Individuals will occasionally get off of the rocks and wander over the snow surface, but this is uncommon. In California adults emerge from December to March.

Genus *Hesperoboreus* Penny

Hesperoboreus is a genus of rather small boreids (less than 4 mm long) with a broad hypostomal bridge to the rostrum. Males have a ninth tergum with a medial notch and no central hood for receiving the dististyles. Females have an ovipositor about half the length of the rostrum. This genus contains only two species—*H. brevicaudus* from western Oregon and Washington and *H. notoperates* from southern California.

Hesperoboreus brevicaudus (Byers, 1961)

This is a lowland species usually found below 600 m west of the Cascade Range in Oregon and Washington. Individuals have been collected by Berlese funnel extraction from mosses, holding a beating sheet under vertical moss banks and scraping the moss surface, or capturing them walking on the snow surface on warm winter days. Russell (1979) mentions their presence in epiphytic mosses in moist forests. Collection records are from 16 October to 31 December, perhaps indicating a somewhat earlier emergence than other species.

They are not known from California, but can probably be found in the northern coastal regions of the state, as they have been taken southwest of Williams, Oregon only 24 km (15 miles) from the California border (Penny 1977).

Hesperoboreus notoperates (Cooper, 1972)

Boreids are known to be cold-adapted insects, and as their name implies, are distributed almost completely in boreal habitats. However, this species is found on Mt. San Jacinto in the Upper Sonoran region of chaparral and yellow pine of southern California at 33.7° north latitude (Map 2), making this the southernmost species of the family (Cooper 1972). Larvae appear to go through four moults during a two year life cycle, metamorphose to pupae in mid-August and September, and emerge as adults from mid-November to mid-March (Cooper 1974). During the long, dry summers when the moss mats are dry and friable, the larva forms a small cell around itself, apparently from salivary secretions. After an occasional summer rain and at the beginning of the fall rainy season they immediately break out of their cells and begin feeding (Cooper 1974). They are found on the northwest slopes of steep canyons in only two places—



MAP 2. Distribution of *Boreus californicus* and *Hesperoboreus notoperates* in California.



FIGURE 3. *Boreus californicus* Packard. Photo by D.D. Wilder.

Larvae appear to go through four moults during a two year life cycle, metamorphose to pupae in mid-August and September, and emerge as adults from mid-November to mid-March (Cooper 1974). During the long, dry summers when the moss mats are dry and friable, the larva forms a small cell around itself, apparently from salivary secretions. After an occasional summer rain and at the beginning of the fall rainy season they immediately break out of their cells and begin feeding (Cooper 1974). They are found on the northwest slopes of steep canyons in only two places—

at 1210 m elevation in Coldwater Canyon, and at 1645 m elevation in Black Canyon on Mount San Jacinto, Riverside County, California (Cooper 1974).

Family Panorpididae

This family is thought to be closely related to Panorpidae (true scorpion-flies), but is phytophagous rather than saprophagous. Adults have smooth tarsal claws, rather than the toothed claws of Panorpididae. Also, larvae of *Brachypanorpa* (and by inference *Panorpodes*) are scarabaeiform and subterranean, while larvae of Panorpididae live at the soil surface and are eruciform (Byers 1965). The family contains only two genera, *Brachypanorpa* and *Panorpodes* distributed in North America, Korea, and Japan.

Genus *Brachypanorpa* Carpenter

Brachypanorpa, as the name implies, have brachypterous females that are flightless. The long rostrum that is so characteristic of Mecoptera is much reduced in *Brachypanorpa*. The sedentary larvae live in the soil of moist forests where they are presumed to feed on plant roots, and adults emerge in early summer. Little else is known of their life history. There are five species recognized, 2 in the eastern U.S. and 3 in the West. The western species include *B. montana* Carpenter in Oregon, *B. oregonensis* McLachlan in California, Oregon, Idaho, and Utah, and *B. sacajawea* Byers in Idaho and Montana.

Brachypanorpa oregonensis McLachlan, 1881

This is the most widely distributed species of *Brachypanorpa*, but is known from only a single locality in California, at Patrick's Point State Park in Humboldt County (Map 3). Adults can be found in early June resting on dense beds of false lilies-of-the-valley (*Malanthemum dilatatum* [Alph. Wood] Nelson and J.F. Macbr.) near the campground. This small population is only a few hundred meters from the Pacific Ocean and may exist here only because of the moderating influence of the nearby ocean currents. Because females are flightless, dispersal is extremely limited. Any perturbation, such as a climate shift or expansion of the campground, could easily eliminate this population.

Genus *Panorpodes* McLachlan

Panorpodes, unlike *Brachypanorpa*, have fully winged females. The rostrum is long in *Panorpodes* and they are more robust, rapid fliers. They live in more open habitats, exposed to sun and wind. Until 2005 they were known only from Korea (1 species) and Japan (2 species) when Byers (2005) described a species from the northern Sierra Nevada of California.

Panorpodes colei Byers, 2005

Fig. 4.

At first glance this appears to be a true scorpion-fly found far outside its known generic range. It has the long rostrum and transparent wings with dark spots so commonly associated with *Panorpa*. However, a careful inspection discloses the smooth tarsal claws and rather thick abdomen. The wings and abdomen have an amber tint. Females are fully winged and both sexes are strong fliers, much faster than most panorpidids.

Adults can be found between 1815 and 1907 m (5900–6200 ft) along the Pacific Crest Trail near Buck's Lake in the high Sierra Nevada (Map 3). The area is covered with deep snow in the

winter and most of the vegetation is low, woody shrubs with a few taller pines. Adults are seen resting on the shrubs in bright sunlight during the early morning, but seem to disappear during the afternoon when temperatures are warmest. For now, they are only known from this one mountainside.

Family Panorpidae (scorpion-flies)

True scorpion-flies (*Panorpa* sp.) are known from eastern North America as far west as southern Manitoba, Canada, eastern Kansas, and central Texas. Although it is highly unlikely that *Panorpa* will ever be found in the state of California, records exist for true scorpion-flies much closer to the state than most people realize. Mexican populations are found as far north as the Sierra Madre Occidental behind Mazatlan, about 1300 km (806 miles) southeast of the California border and records exist for Utah localities less than 900 km (558 miles) east of California.

In 1937, Ashley Gurney described a new species of *Panorpa* from Uintah Canyon and Whiterocks, Utah. He also included new records for *Panorpa venosa* Westwood (now *P. helena* Byers) from the same localities. These distribution records extended the known range for this genus by about 1210 km (750 miles). Frank Carpenter studied the new species and reidentified the males as *Panorpa submaculosa* Carpenter and the females as *Panorpa maculosa* Hagen. Carpenter also questioned the validity of the collection records. However, the collector Fred Harmston, reported that he believed the locality information was accurate (Gurney 1938). No additional specimens have ever been collected there. George Byers (pers. commun.) has been to the locality and, although he didn't find any *Panorpa* at this spot, said that the locality looked like good *Panorpa* habitat.

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MAP 3. Distribution of *Panorpodes colei* and *Brachypanorpa oregonensis* in California.



FIGURE 4. *Panorpodes colei* Byers. Photo by Wes Bicha.

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